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Naval Command,
Control and Ocean
Surveillance Center RDT&E Division San Diego, CA
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Technical Document 2727
December 1994

Analysis of Historical Oceanographic Data on a Minicomputer

Program WAHOO

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San Diego, California 92152–5001

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ADMINISTRATIVE INFORMATION

Work for this report was performed by the Advanced Systems Operations Branch (Code 742) of the Advanced Surveillance Concepts and Systems Engineering Division (Code 74) of the Naval Command, Control and Ocean Surveillance Center RDT&E Division, San Diego, California.

Released by
G. S. Sprouse, Acting Head
Advanced Systems
Operations Branch

Under authority of
M. R. Akers, Jr., Head
Advanced Surveillance Concepts
and Systems Engineering Division

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INTRODUCTION

The Master Oceanographic Observation Data Set (MOODS), maintained by the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi, is the standard Navy database for oceanographic observations (references 1 and 2). Data contained in MOODS include observations of thermal and chemical properties of the water column from surface to bottom, the biota and currents in the water column, and the underlying sea floor as collected by oceanographic agencies worldwide. Although MOODS provides the most comprehensive collection of oceanographic data available, these data require analysis to provide insight into oceanographic processes in regions of interest both to operational Naval forces and Navy Laboratories. Because these regions frequently change in response to world politics, the Navy must be able to examine regional ocean characteristics whenever and wherever desired.

This document describes software developed at the Naval Command, Control and Ocean Surveillance Center, RTD&E Division (NRaD), to process regional sets of expendable bathythermograph (XBT), ocean station (OSTA), or hydrocast and conductivity-temperature-depth (C–T–D)/salinity-temperature-depth (S–T–D) observations resident in MOODS. Included software offers a wide variety of options to filter, process, analyze, and display data.

The majority of programs described in the document are installed on a Sun SPARC 10 (host code WAHOO); while two routines are programmed for the MS/DOS operating system installed in a 386-series microcomputer. Operating guidelines for these routines are provided in appendix A and appendix B, respectively.

ARCHIVED DATA

The original unclassified MOODS data are located on 9-track tapes located in the NRaD Code 713 secure storage facility. Processed regional files are stored on WAHOO and may be accessed by many of the programs described in this document. Criteria for the construction of regional files were based on two factors: (1) natural geographic divisions such as shorelines, island chains, continental shelves, etc., and (2) the number of data available. Regions are not constrained to rectangles, but may be downloaded into complex shapes using (1) least-squares fit of latitude/longitude and (2) a combination of subareas using the MS/DOS COPY command. An example of a regional file is SOCAL.MBT, which contains all available XBT data for the Southern California Bight. Figures 1 through 5 provide the names and locations for MOODS data currently available on WAHOO.

The MOODS database was revised in 1993 to conform with security requirements. These data are available from NAVOCEANO Code N3211 on diskettes with individual data files. These files must be preprocessed on an IBM-compatible personal computer using Routine NUMDS (reference 3) and uploaded to WAHOO using the Microcopy Protocol (MCP) before they can be accessed with the programs described in this document.[1] Theoretically, larger data sets could be transferred electronically from NAVOCEANO using the File Transfer Protocol (FTP), but this technique has not been verified at this time.

Data files saved by WAHOO may be either used by other programs or downloaded via MCP to a personal computer for use with Program MDS (reference 4).

1 Instructions for using MCP can be obtained from the Custom Service Group, NRaD Code 02902.

DATA SECURITY

MOODS data contains both classified and unclassified data. However, because WAHOO is an unclassified system, only unclassified data can be processed on this machine. Classified data may be processed using Routines NUMDS and MDS on MUNICH, located in the Bayside Acoustic System Computing Center (BASCC) in Building 1, Bayside. Permission to use this system must be certified by the BASCC Security Officer.

PROGRAM DESCRIPTION

ROUTINE CKREEL

Routine CKREEL examines a 9-track reel and lists the data included in each 10-degree rectangle as shown in figure 6. This listing is necessary to ensure that all data are accessed when building regional files using Routine XBT0.

The program uses World Meteorological Organization (WMO) codes to indicate the general position of the data. The first digit of the 10-degree code represents the quadrant of the earth (1:NE, 3:SE, 5:SW, 7:NW), the second the first digit of latitude, and the last two the first and second digits of longitude. For example, the first 10-degree rectangle shown in figure 6 (7215) is decoded as 20°N, 150°W. One-degree WMO codes ranging from 00 to 99 refine the position of the first and last observations included in the larger rectangle. In this case, 57 indicates 5 and 7 degrees for latitude and longitude, respectively. This adjusts the position of the first observation to 25°N, 157°W, which is within a few nautical miles of the actual position of 25°49'N, 157°30'W. The listing also shows that WMO rectangle 7215 contains 3081 of the 10,391 XBT traces included on reel U15978.

ROUTINE XBT0

Routine XBT0 is the basic routine for downloading data from 9-track tape reels to regional files. Data for the files shown in figures 1 through 5 were generated using this program. The strength of this program is the ability to use algorithms generated by Routine LSTSQRS to represent nonlinear boundaries when defining regional limits. Figure 7 illustrates output from this program listing the number of observations for each type data downloaded. File names are the same for all data formats, with type of observation indicated by file extension (.MBT, .MOS, or .MST). Algorithms used to define the region are printed as well as administrative information.

ROUTINE DWNLD

Regional data files may be edited for use in the analysis routines described below or for downloading to a personal computer for later processing. In the latter case, smoothing of XBT and C–T–D/S–T–D data substantially reduces the time required to download the file. The limited numbers of data points in a hydrocast (maximum: 32) negates the advantage of processing these data with DWNLD.

ROUTINE XBT2A

Routine XBT2A is the major data analysis routine for XBT data. Statistical output is in two sections: (1) temperature at nine levels, sonic layer depth[2], and temperature gradient between 200 and 300 m (DT23), and (2) characteristics of the near-surface sound channel. Choice of periods (biweekly to annual) and geographic filters are available. Frequency of phenomena such as zero

[2] Definitions for acoustic parameters used in the programs described in the text are given in appendix C.

sonic layer, half channel, and useful sound channels are printed below the statistical information. Salinity from three sources may be used for sound speed computations: (1) constant salinity of 35 parts per thousand (o/oo), (2) a single user-provided salinity profile, or (3) seasonal profiles generated using Routine TSZ. The distribution of observation per 30-minute rectangles over a 10- by 10-degree area[3] may be printed and saved. Examples of statistical printout as a function of month are shown as figures 8 and 9. Figure 10 shows a typical miniplot printout. In this plot, limited data to the southwest (lower left corner of the plot) shows the effect of limited observations owing to shallow water, whereas limited observations to the northeast are the result of a data filter. Crude plots of temperature values at a selected depth (figure 11) and DT23 may be printed. The data may be stored in two formats: (1) the statistical data for use with routines XSIG and CUMLTV and (2) number of observation per 30–minute rectangle for use with Routine MRGEXY.

Note: Sound channel statistics are computed for that channel having the lowest cutoff frequency. In geographic regions where the deep sound channel approaches the surface, Program MDS cannot reliably discern the difference between deep and secondary sound channels. This problem is mitigated by the fact that, for most tactical purposes, sonic energy travels equally well in both ducts.

Note: Because of the considerable variability that occurs in the upper layer of the sea, statistical computations should be made for 1-month periods only.

Note: Remember that values computed with less than 30 samples are not reliable statistically.

ROUTINE TSZ

Hydrocast and C–S–T/S–T–D data are used to provide (1) a crude T–S scatter plot at a user-defined depth and (2) seasonal salinity profiles with respect to depth. The profiles may saved as a source of salinity input into Routine XBT2A. Examples of printout from this program are shown as figures 12 and 13.

ROUTINE XBT3A

This routine uses hydrocast and C–S–T/S–T–D data to (1) generate miniplots similar to those in Routine XBT2A and (2) mean, standard deviation, and number of observations per 1-degree rectangle for temperature, salinity, sound speed, or density. The miniplot may be stored for later use by Routine MRGEXY. An example of output in the latter configuration is shown in figure 14.

ROUTINE XSIG

Level of significance between parameters from data sets generated and saved by XBT2A can be determined using Routine XSIG. This can be particularly helpful in determining similarities and differences between data sets, thereby permitting inferences about a geographic region. For example, significance differences between temperature at most levels from adjacent areas strongly suggests presence of an oceanic front. Conversely, if no significance is found, the data are from the same water mass and may be combined using Routine CUMLTV. This implies that careful examination is required within each area to separate the data into separate water masses. A typical printout from XSIG is shown in figure 15.

3. Henceforth referred to as a "miniplot."

ROUTINE CUMLTV

Statistical data sets generated and saved using Routine XBT2A can be combined into a single data set and printed with Routine CUMLTV. This function is particularly useful when the number of observations in a given area is insufficient to provide meaningful statistics or where the area of interest includes more than one region. Output is similar to that of Routine XBT2A.

ROUTINE MRGEXY

Routine MRGEXY can be used to determine water mass distribution by combining stored miniplots generated by Routines XBT2A and XBT3A. Up to four water masses may be included; however, you must ensure that all miniplots for a given water mass were computed using identical parameters. Stored miniplots are adjusted automatically for differences in geographic coverage to correspond with the area designated by the program. Output includes percentage of total number of observations by water mass by 30-minute and 1-degree rectangle. An example showing the percentage of water typical of the east central North Pacific Ocean is shown in figure 16. Note that the historical data included in MOODS span several decades; therefore, implied water mass boundaries represent only the general position of an ocean front, not the location at a specific time. Furthermore, data from all seasons are used, and ephemeral fronts may be masked by this process. A plot showing the relative location of ocean features seaward of California as generated using output from Routine MRGEXY is shown in figure 17.

ROUTINE LSTSQRS

LSTSQRS is a PC routine for least-squares fit of data sets such as latitude versus longitude or temperature versus salinity. Routines XBT0, DWNLD, and XBT2A use the algorithms generated by LSTSQRS to determine the boundaries for a geographic filter. Figures 18 and 19[4] show typical output for the analysis and a copy of the PC monitor showing the goodness of fit, respectively.

ROUTINE XYPLOT

XYPLOT is a PC program that produces plots using the output from Routine XBT2A. The data may be used to (1) plot monthly mean and standard deviation of temperature, salinity, and acoustic parameters versus depth, (2) frequency of observations such as zero sonic layer depth or useful sound channels, and (3) monthly mean of multiple parameters such as temperature at different depths. Typical plots are shown as figures 20 through 22. These plots are useful in illustrating the magnitude of temporal change.

[4] These and other graphics captured from a PC monitor were made using Deluxe Paint II Enhanced, a product of Electronic Arts, Inc.

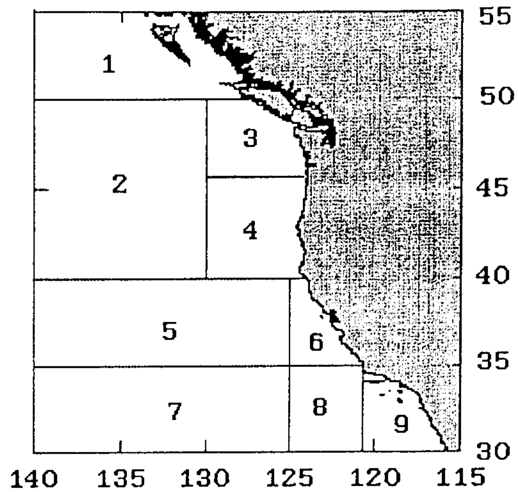
REFERENCES

1. Bauer, R.. "Functional Description: Master Oceanographic Observation Data Set (MOODS)," Compass Systems Inc., 1982.

2. Jugan, M.J. and H. Beresford. "Editing Approach for the Navy's Master Oceanographic Observation Data Set," published in *Proceedings of MTS '91, An Ocean Cooperative: Industry, Government, and Academia, Vol II*, 1992.

3. Fisher, A., Jr.. "Downloading Environmental Data in the New MOODS Format; Program NUMDS," NRaD Technical Document 2696, NCCOSC RDT&E Division, San Diego, CA, 1994.

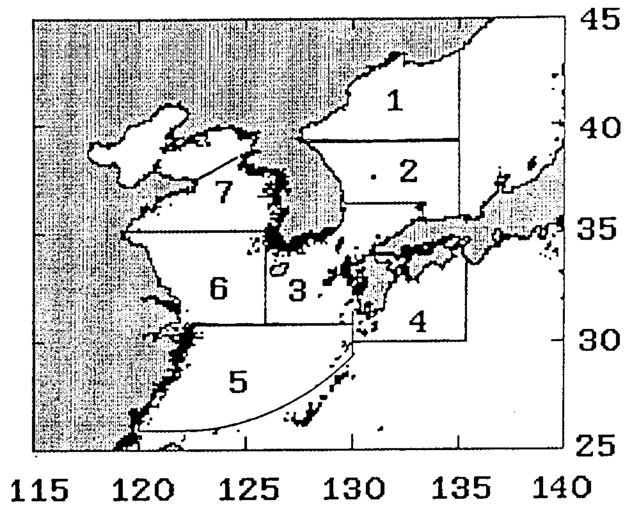
4. Fisher, A., Jr.. "Analysis of Historical Oceanographic Data with a Personal Computer; Program MDS," NRaD Technical Document 2703, NCCOSC RDT&E Division, San Diego, CA, 1994.



LEGEND:

1 CANNW 2 EPAC1 3 ASJDF
4 PACNW 5 EPAC2 6 NOCAL
7 EPAC3 8 EPAC3A 9 SOCAL

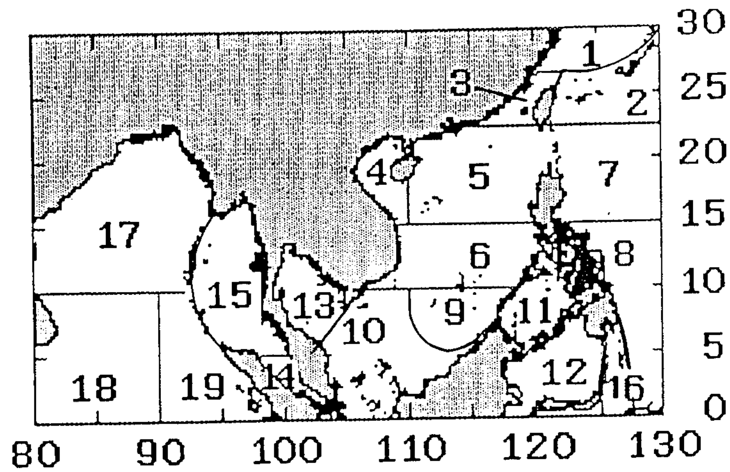
Figure 1. Regional files for the northeastern Pacific Ocean.



LEGEND:

1 NWSOJ 2 SWSOJ 3 KOREA
4 EKYU 5 ECHINA1 6 SYELLOW
7 NYELLOW

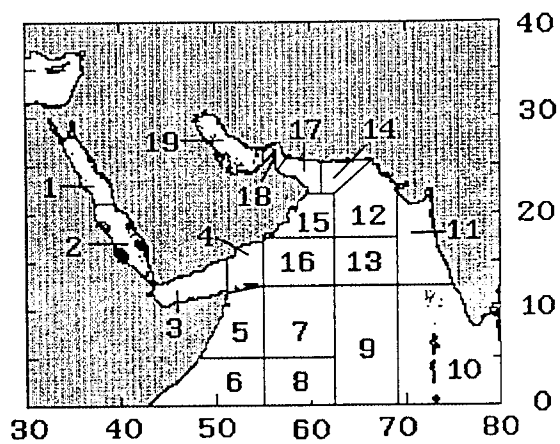
Figure 2. Regional files for the western Pacific Ocean.



LEGEND:

1 ECHINA1	2 ECHINA2	3 BASHI	4 TONKN
5 SCHINA1	6 SCHINA2	7 EPHIL1	8 EPHIL2
9 SCHINA3	10 SUNDA	11 SULU	12 CELBS
13 THAI	14 MALAC	15 ANDMN	16 NMOLUC
17 NBNGL	18 SWBNGL	19 SEBNGL	

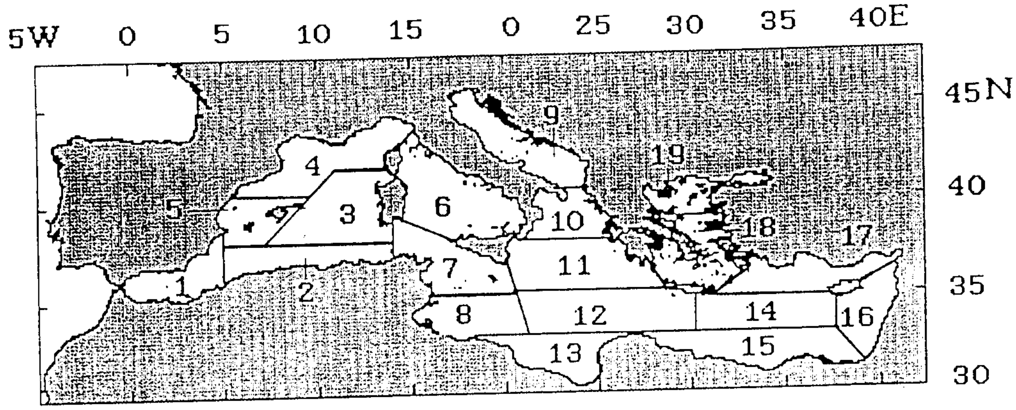
Figure 3. Regional files for Southeast Asia and the Bay of Bengal.



LEGEND:

1 NRED	2 SRED	3 ADENW
4 ADENE	5 NSOMALIA	6 SSOMALIA
7 WARBN1	8 WARBN2	9 CARBN
10 EARBN	11 NEARBN	12 NCARBN1
13 NCARBN2	14 PAK	15 NWARBN1
16 NWARBN2	17 GOMAN	18 STRHOR
19 PERSNG		

Figure 4. Regional files for the Arabian Sea and adjacent areas.



LEGEND:

1 ALBORAN	2 NAFRICAN	3 ALGERIAN	4 SFRANCE
5 VAL	6 TYRR	7 STRSIC	8 LIBYA
9 ADRIATIC	10 IONIAN1	11 IONIAN2	12 IONIAN3
13 SIDRA	14 EMED	15 SEMED	16 LEVANT
17 NEMED	18 AEGNS	19 AEGNN	

Figure 5. Regional files for the Mediterranean Sea.

```
NODC XBT DATA ON REEL U15978

                 WMO  SQRS                 POSITION
            10-DEGR    1-DEGR          LAT          LON          OBS


START:        7215         57        25-49N     157-30W
END:                       99        29-28N     159-34W         3081


START:        7216          0        20- 2N     160-41W
END:                       99        29-25N     169-50W         4282


START:        7217          0        20-47N     170-50W
LAST:                      99        29- 0N     179-14W         3028


COMPLETED READING REEL U15978

TOTAL OBS:   10391



PROGRAM FINISHED
FORTRAN STOP
$
```

Figure 6. Typical listing of tape contents generated by Routine CKREEL.

FILE: CANNW
DATE: 6-MAY-93

NUMBER XBT TRACES SAVED: 2365

NUMBER HYDROCASTS SAVED: 1039

NUMBER STD/CTD OBS SAVED: 1043

NUMBER WRITE ERRORS: 0

NUMBER REJECTED OBS: 1621

START TIME: 1220.2 END TIME: 1228.3

DATA FROM REEL X1775 , FL 2, DOWNLOADED TO FILE CANNW

ALGORITHM TERMS:

NORTH	SOUTH	EAST	WEST
55.00000000	50.00000000	57.74202000	140.00000000
0.00000000	0.00000000	1.63092500	0.00000000
0.00000000	0.00000000	-0.04202001	0.00000000
0.00000000	0.00000000	0.00064859	0.00000000
0.00000000	0.00000000	0.00000306	0.00000000
0.00000000	0.00000000	0.00000020	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

NUMBER OF OBS PROCESSED: 19698

Figure 7. Inventory of regional data downloaded using Routine XBT0.

SAN DIEGO DEEP [S: SOCAL]

PERIOD = JANUARY NUMBER OF OBSERVATIONS = 1340

LEVEL	0	25	50	100	150	200	300	400	SLD	T SLD	DT 2/3	SD COF
MEAN	15.06	14.90	13.98	11.11	9.93	9.21	8.11	7.20	24.7	15.12	-1.10	1802.6
MAX	21.9	21.0	19.5	16.2	16.1	16.2	16.4	16.1	91	21.9	0.5	43280
MIN	6.3	10.4	9.6	8.8	7.9	7.3	6.4	5.4	0	11.5	-2.4	0
RANGE	15.6	10.7	9.9	7.4	8.2	8.9	10.0	10.7	91	10.4	2.9	43280
STD DEV	1.22	1.25	1.46	1.02	0.75	0.68	0.66	0.60	20.9	1.21	0.31	2831.4

PCT ZERO SLD: 23.5 PCT SLD AT 400M OR GRTR: 0.0 PCT HALF CHANNELS: 0.0

PERIOD = FEBRUARY NUMBER OF OBSERVATIONS = 1219

LEVEL	0	25	50	100	150	200	300	400	SLD	T SLD	DT 2/3	SD COF
MEAN	14.93	14.73	13.86	11.10	9.87	9.15	8.00	7.10	24.8	14.98	-1.14	1855.9
MAX	18.2	20.7	18.2	15.6	13.9	13.2	12.3	12.1	86	20.8	0.7	34306
MIN	11.8	11.5	10.2	8.9	8.1	7.6	5.9	5.2	0	12.0	-2.8	0
RANGE	6.4	9.1	8.0	6.7	5.8	5.6	6.4	6.9	86	8.8	3.6	34306
STD DEV	1.02	1.07	1.35	0.94	0.65	0.60	0.61	0.60	22.0	1.04	0.33	2945.1

PCT ZERO SLD: 22.5 PCT SLD AT 400M OR GRTR: 0.0 PCT HALF CHANNELS: 0.0

PERIOD = MARCH NUMBER OF OBSERVATIONS = 1322

LEVEL	0	25	50	100	150	200	300	400	SLD	T SLD	DT 2/3	SD COF
MEAN	14.81	14.44	13.25	10.74	9.64	8.96	7.92	7.06	19.2	14.84	-1.04	2366.1
MAX	20.8	20.6	20.2	18.1	15.9	14.9	14.3	14.4	95	20.8	0.3	41470
MIN	11.4	10.0	9.7	8.7	8.0	7.0	6.2	5.6	0	11.2	-2.3	0
RANGE	9.4	10.6	10.5	9.4	8.0	7.9	8.1	8.8	95	9.6	2.7	41470
STD DEV	1.00	1.06	1.32	0.89	0.66	0.63	0.63	0.58	20.1	1.00	0.31	3772.7

PCT ZERO SLD: 29.7 PCT SLD AT 400M OR GRTR: 0.0 PCT HALF CHANNELS: 0.0

Figure 8. Statistical computations in the near-surface layer generated using Routine XBT2A.

SAN DIEGO DEEP [S: SOCAL]

PERIOD = JANUARY NUMBER OF OBSERVATIONS WITH USEFUL SOUND CHANNELS = 730

FEATURE	AXIAL DEPTH	AXIAL TEMP	S.C. THICKNESS	S.C. MAGNITUDE	S.C. STRENGTH	LOW FREQ CUT OFF
MEAN OF USEFUL S.C.	228.1	8.87	61.1	0.8	3.8	401.6
MAX OF USEFUL S.C.	439	17.1	248	10.0	47.7	794
MIN OF USEFUL S.C.	3	6.27	11	0.1	0.8	21
STD DEV OF USEFUL S.C.	88.2	1.61	29.6	0.8	3.7	192.0

PCT OBS WITH SC: 100.0 PCT OBS WITH USEFUL SC: 54.5 PCT OBS WITH MULTIPLE SC: 100.0

PERIOD = FEBRUARY NUMBER OF OBSERVATIONS WITH USEFUL SOUND CHANNELS = 608

FEATURE	AXIAL DEPTH	AXIAL TEMP	S.C. THICKNESS	S.C. MAGNITUDE	S.C. STRENGTH	LOW FREQ CUT OFF
MEAN OF USEFUL S.C.	229.9	8.74	62.4	0.9	3.8	387.4
MAX OF USEFUL S.C.	585	16.6	196	9.4	31.3	798
MIN OF USEFUL S.C	1	5.95	15	0.1	1.3	33
STD DEV OF USEFUL S.C.	88.7	1.55	28.7	0.8	2.9	194.2

PCT OBS WITH SC: 100.0 PCT OBS WITH USEFUL SC: 49.9 PCT OBS WITH MULTIPLE SC: 100.0

PERIOD = MARCH NUMBER OF OBSERVATIONS WITH USEFUL SOUND CHANNELS = 739

FEATURE	AXIAL DEPTH	AXIAL TEMP	S.C. THICKNESS	S.C. MAGNITUDE	S.C. STRENGTH	LOW FREQ CUT OFF
MEAN OF USEFUL S.C.	228.8	8.64	68.4	0.8	4.2	362.3
MAX OF USEFUL S.C.	824	15.9	286	6.6	46.8	796
MIN OF USEFUL S.C.	1	5.32	16	0.1	1.0	22
STD DEV OF USEFUL S.C.	92.6	1.55	32.5	0.7	3.6	192.4

PCT OBS WITH SC: 100.0 PCT OBS WITH USEFUL SC: 55.9 PCT OBS WITH MULTIPLE SC: 100.0

Figure 9. Statistical computations in the sound channel generated with Routine XBT2A.

STR OF SICILY COMPOSITE

40N

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	152	137	74	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129	94	109	81	98	43	3	0	0	0	0	0	0	0	0	0	0	0	0	0
48	56	59	9	38	32	15	1	0	0	0	0	0	0	0	0	0	0	0	0
4	2	6	14	42	38	11	19	21	5	1	0	0	0	0	0	0	0	0	0
0	0	1	0	3	23	68	66	81	87	45	11	5	0	0	0	0	0	0	0
0	0	0	3	3	2	28	35	38	57	59	21	21	0	0	0	0	0	0	0
0	0	0	1	1	2	3	8	34	42	27	12	33	20	0	0	0	0	0	0
0	0	0	0	0	0	1	2	7	22	50	60	44	42	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

30 N

9 E — 19 E

Figure 10. Example of a miniplot produced by Routine XBT2A.

```
DATA:  SAN DIEGO DEEP [S: SOCAL]                                DEPTH:200 M

TEMP   OBS    PCT
                    |
           1   0.0  |*
 6         1   0.0  |*
           2   0.0  |*
 7        19   0.1  |*
         214   1.5  |***
 8      2288  17.0  |***********************
        4876  36.3  |*************************************************
 9      3493  26.0  |***********************************
        1567  11.6  |****************
10       594   4.4  |******
         202   1.5  |***
11        76   0.5  |*
          31   0.2  |*
12         6   0.0  |*
           8   0.0  |*
13         9   0.0  |*
           4   0.0  |*
14         6   0.0  |*
           2   0.0  |*
15         2   0.0  |*
           0   0.0  |
16         2   0.0  |*
           0   0.0  |
17         1   0.0  |*
           1   0.0  |*
18         0   0.0  |
           0   0.0  |
19         0   0.0  |
           0   0.0  |
20         0   0.0  |
           0   0.0  |
21         0   0.0  |
           0   0.0  |
22         0   0.0  |
           1   0.0  |*

SUM OBS:  13406
ESTIMATE OF MEAN:     8.7 DEGR C
```

Figure 11. Temperature histogram printed by Routine XBT2A.

EASTPAC NE LEVEL: 125 M, 6262 OF **** OBS ACCEPTED

20.0

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
0	0	0	1	0	2	2	1	0	2	1	0	0	0	0	0	0	0	0	0	9
0	0	1	3	2	14	14	20	32	28	49	25	5	3	0	0	0	0	0	0	196
0	0	1	5	0	9	28	67	136	234	564	864	211	14	1	1	0	0	0	0	2135
0	0	1	2	8	19	54	120	235	369	695	1145	722	63	1	1	0	0	0	0	3435
0	1	0	0	0	5	14	26	53	43	63	70	127	68	3	0	0	0	0	0	473
0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	0	0	0	9
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0.0

32.00 35.00

Figure 12. A T–S scatter plot from Routine TSZ.

NORCAL CALIF C. [S50 < 33.25]

SUMMER

DEPTH	OBS	TEMPERATURE MEAN	TEMPERATURE S.D.	SALINITY MEAN	SALINITY S.D.	SOUND SPEED MEAN	SOUND SPEED S.D.
0	15	13.31	1.63	32.96	0.25	1499.0	5.2
10	15	12.94	1.61	32.98	0.23	1497.9	5.5
20	15	11.91	1.30	32.97	0.17	1494.7	4.6
30	15	10.72	0.92	32.95	0.15	1490.7	3.4
50	16	9.35	0.63	33.01	0.17	1488.2	2.1
75	15	8.92	0.64	33.27	0.22	1486.3	2.6
100	15	8.75	0.51	33.48	0.19	1485.4	2.0
125	14	8.59	0.52	33.62	0.18	1485.4	1.9
150	14	8.26	0.55	33.76	0.15	1484.7	2.0
200	14	7.66	0.46	33.91	0.14	1483.5	1.7
250	13	7.17	0.45	33.96	0.18	1482.5	1.7
300	11	6.78	0.47	34.00	0.11	1481.7	1.8
400	9	6.13	0.48	34.12	0.07	1481.1	1.9
500	6	5.57	0.33	34.16	0.11	1480.6	1.3
600	5	5.13	0.38	34.23	0.09	1480.6	1.5
800	5	4.34	0.21	34.32	0.07	1480.8	0.9
1000	4	3.70	0.09	34.32	0.19	1481.6	0.4

DEEP SOUND CHANNEL AXIS: 500 M

NORCAL CALIF C. [S50 < 33.25]

AUTUMN

DEPTH	OBS	TEMPERATURE MEAN	TEMPERATURE S.D.	SALINITY MEAN	SALINITY S.D.	SOUND SPEED MEAN	SOUND SPEED S.D.
0	10	14.00	1.26	33.01	0.24	1501.4	4.3
10	10	13.77	1.09	33.01	0.21	1500.8	3.8
20	10	13.00	0.94	33.02	0.15	1498.4	3.3
30	10	11.78	0.92	33.04	0.13	1494.5	3.2
50	10	9.73	0.31	33.07	0.17	1487.6	1.2
75	10	9.23	0.45	33.37	0.15	1486.6	1.8
100	10	8.85	0.28	33.62	0.11	1485.9	1.1
125	10	8.55	0.31	33.79	0.12	1485.4	1.2
150	10	8.26	0.32	33.89	0.11	1484.8	1.2
200	9	7.59	0.17	33.99	0.03	1483.3	0.6
250	9	7.22	0.24	34.05	0.04	1482.7	1.0
300	6	6.65	0.19	34.04	0.05	1481.3	0.8
400	2	5.84	0.20	34.02	0.02	1479.0	0.8
500	1	5.38	0.00	34.10	0.01	1479.8	0.3
600	1	5.08	0.00	34.19	0.01	1480.3	0.1
800	1	4.55	0.00	34.33	0.01	1481.7	0.1
1000	1	3.94	0.00	34.41	0.00	1482.6	0.2

DEEP SOUND CHANNEL AXIS: 400 M

Figure 13. Printout of seasonal profiles from Routine TSZ.

PERIOD 1 S CAL (DEEP WATER) -- TEMP @ 150

DEPTH 150M. TEMPERATURE

40N

0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	36 9.11 0.70	116 9.14 0.43	1 9.62 0.00	0 0.00 0.00
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	304 8.79 0.49	291 9.02 0.50	540 9.29 0.54	177 9.52 0.60
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	130 9.15 0.54	461 8.97 0.54	552 9.07 0.49	462 9.53 0.53
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	120 9.24 0.46	221 9.18 0.54	197 9.32 0.69	254 9.48 0.60
0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	0 0.00 0.00	126 10.10 0.89	160 9.66 0.74	216 9.71 0.66	139 9.55 0.62

30N

127W 117W

DEEP WATER) -- TEMP @ 150

Figure 14. Statistical printout of temperature by 1-degree rectangles produced by Routine XBT3A.

SET 1: EASTPAC COLD [5 TO 10 @ 150 M; SAL: EP3COLD]

SET 2: EASTPAC WARM [10 TO 22 @ 150; SAL: EP3WARM]

		EPCOLD			EPWARM			
SURFACE TEMP	MON	# OB	MEAN	S.D.	# OB	MEAN	S.D.	SIGNIF
	JAN	193	14.09	1.08	517	17.22	1.32	VS @ 99
	FEB	222	14.23	1.18	528	16.66	1.21	VS @ 99
	MAR	246	13.99	1.11	488	16.35	1.09	VS @ 99
	APR	176	13.73	1.29	495	16.26	1.19	VS @ 99
	MAY	175	13.75	1.33	498	17.05	1.26	VS @ 99
	JUN	218	15.20	1.30	822	18.35	1.46	VS @ 99
	JUL	260	15.90	1.18	462	19.76	1.66	VS @ 99
	AUG	238	17.08	1.40	659	20.17	1.50	VS @ 99
	SEP	236	17.64	1.40	386	21.40	1.52	VS @ 99
	OCT	366	17.27	1.14	407	20.52	1.34	VS @ 99
	NOV	249	16.23	1.58	627	19.24	1.13	VS @ 99
	DEC	164	15.41	1.12	359	18.13	1.21	VS @ 99

Figure 15. Printout showing level of significance of a given water mass produced by Routine XBT2A.

PERCENTAGES -- WARM [10-20 2 150 M]

40N										
	0	9000	0	9000	0	0	4000	-999	-999	-999
	4000	9033	0	2	6	0	0	4000	-999	-999
	0	0	1	9000	0	2	1	0	-999	-999
	4000	9014	0	6	3	0	0	2	5	-999
	33	28	25	9022	18	8	3	0	0	1
	58	4075	4033	23	14	6	13	3	0	4
	4000	90	31	47	5	34	15	3	1	1
	4100	-999	9100	4100	58	50	48	14	6	7
	4100	4100	9085	82	85	69	9066	40	16	9
	4100	4100	9100	4100	4100	85	71	59	54	41
30 N										
130 W										120 W

NOTE: -999 INDICATES NO OBS: 400X INDICATES < 5 OBS: 900X INDICATES < 10 OBS.

Figure 16. Frequency of occurrence of a given water mass produced by Routine MRGEXY.

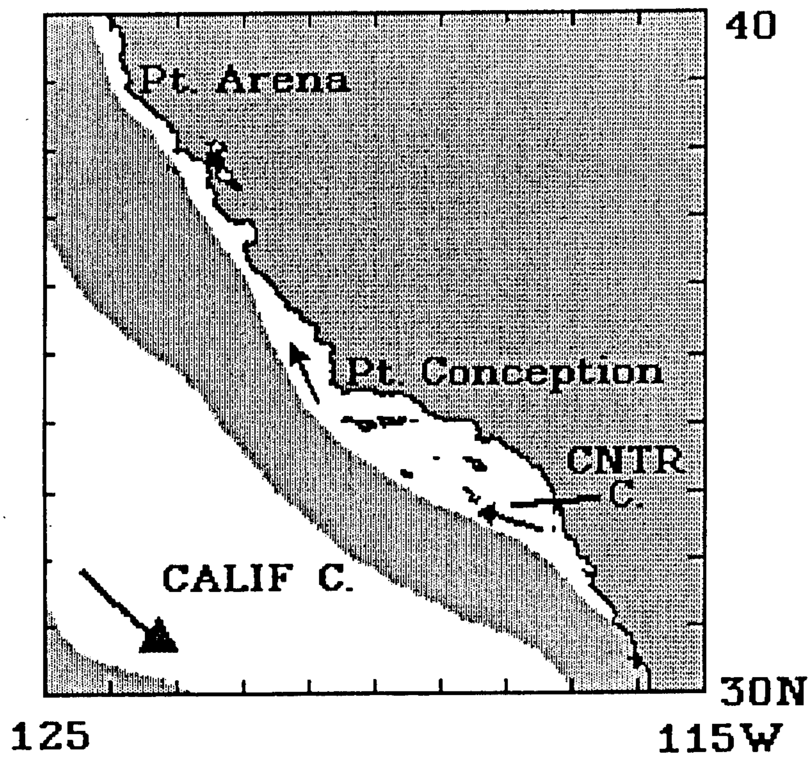


Figure 17. Watermass analysis derived from combined frequency plots.

DATA SET: EASTERN SIDE OF ANDAMAN SEA

POWER	COEFFICIENT
0	127.0306
1	-9.31768
2	1.178889
3	-6.733438E-2
4	1.456577E-3

X(I)	Y(I)	L. S. Y(I)	L.S. ERROR
5.00	102.40	102.41	0.008
7.00	100.00	99.97	-0.026
9.00	99.10	99.13	0.031
11.00	98.90	98.89	-0.015
13.00	98.80	98.80	0.001
15.00	99.00	99.00	0.001

RESIDUAL SUM OF SQUARES: 0.0000

Figure 18. Least-squares fit of a geographic boundary generated by Routine LSTSQRS.

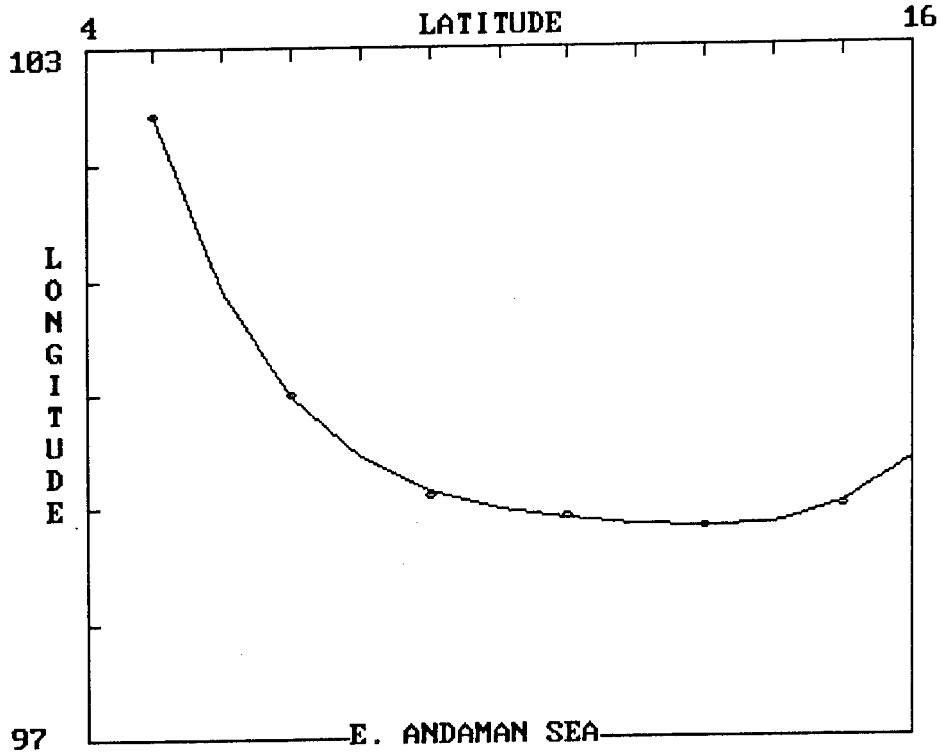


Figure 19. Graphic comparing the least-squares fit to the original data point as computed by Routine LSTSQRS.

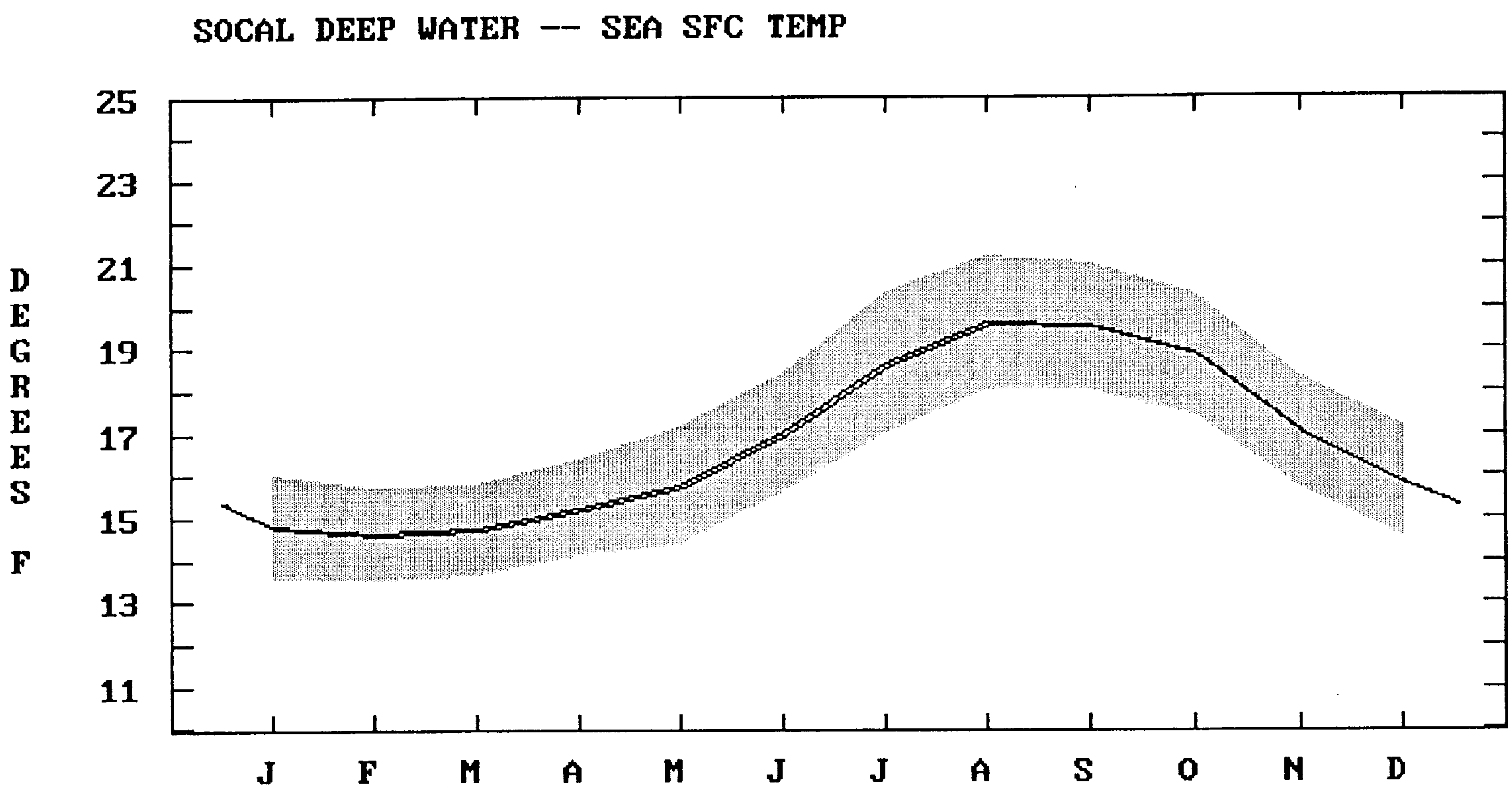


Figure 20. Typical plot showing the monthly mean and variation of sea surface temperature from Routine XYPLOT.

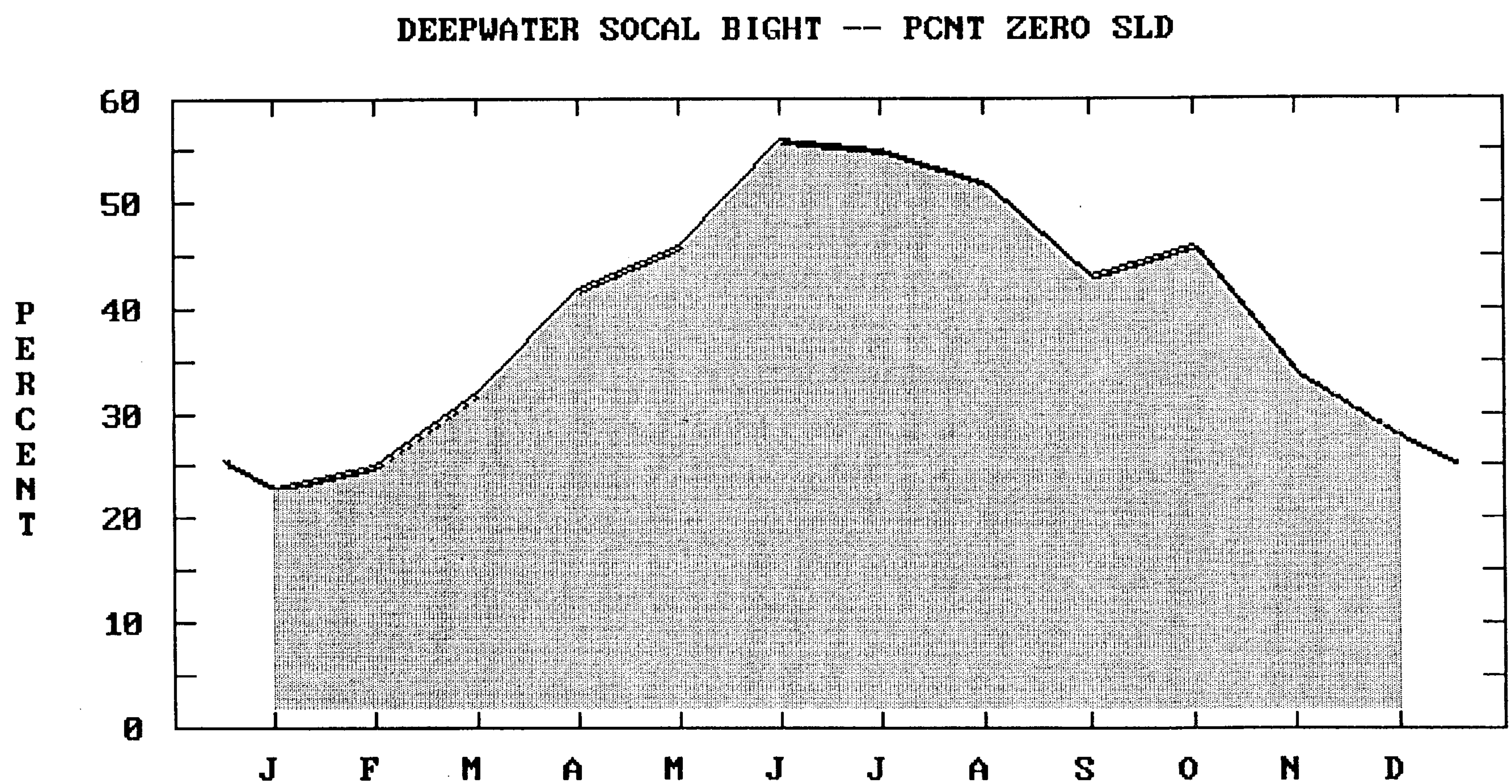


Figure 21. Frequency of zero layer depth plot generated by Routine XYPLOT.

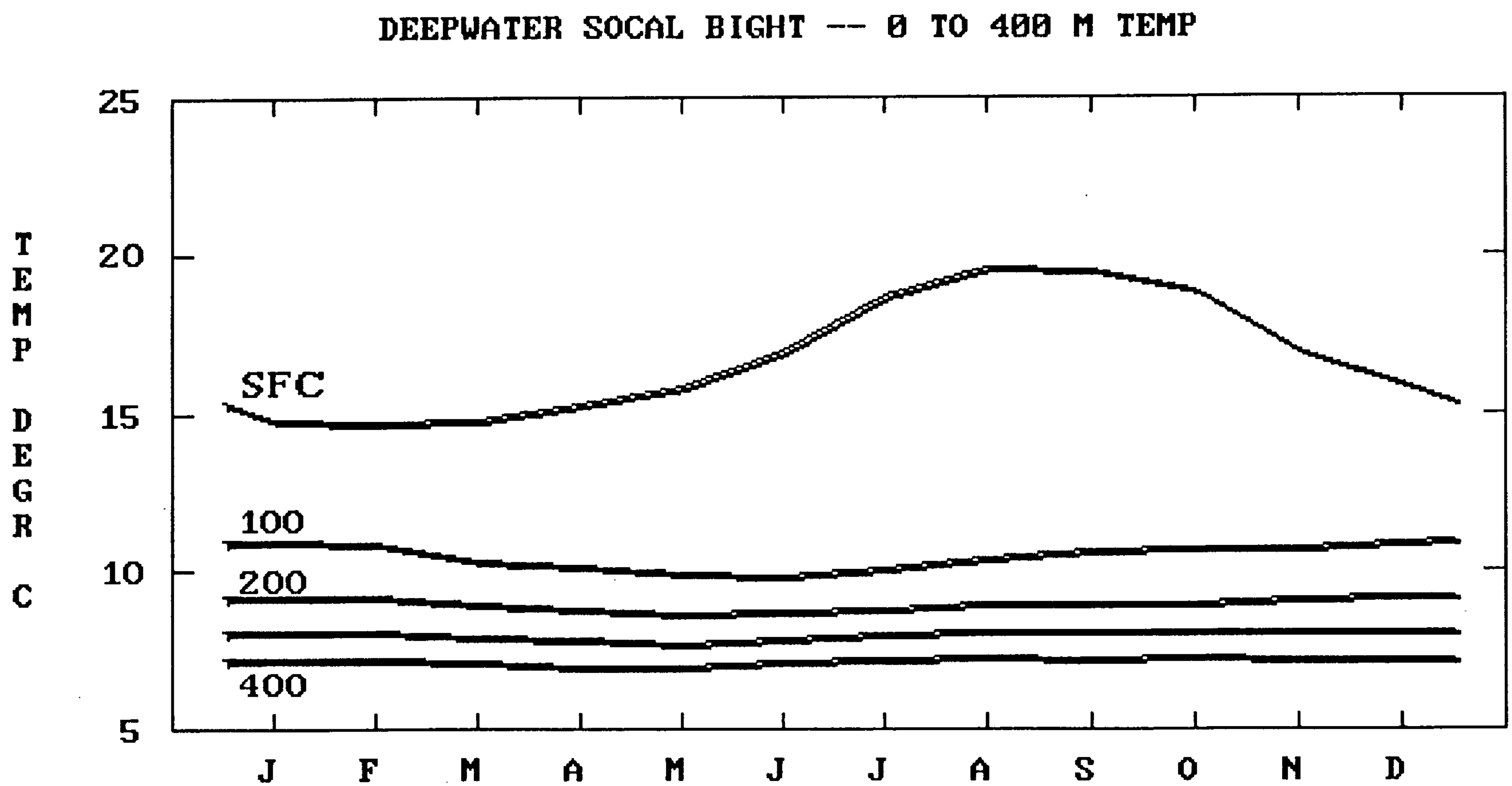


Figure 22. Mean temperature at various levels as plotted by Routine XYPLOT. Note that the labels for each curve were later added manually.

APPENDIX A
PROGRAMS AVAILABLE ON WAHOO

WAHOO is located in the General Purpose Computer Center (GPCC), Room B229, Building 1, Bayside. The system operators will provide general assistance, including mounting tape reels. Output will be placed in bins alphabetically by user name immediately inside Room B229. Questions pertaining to the VMS operating system should be directed to Code 0299.

A1. Most programs described in this text are found on the Sun SPARC 10 Computer network WAHOO. Locations of specific programs described in this document are:

Directory	Routines
XBT0	XBT0 , DWNLD, CHKRL
XBTIA	XSIG
XBT2A	XBT2A, XSIG, CUMLTV
XBT3A	XBT3A, MRGEXY
TSZ	TSZ

Regional files are stored in the following manner:

Directory	Type Data	Extension	No. Files	Blocks
XBT0	C–T–D/S–T–D	.MST	98	125,604
XBT2A	XBT	.MBT	109	275,430
TSZ	Hydrocast	.MOS	99	72,745

A2. WAHOO is accessed using the NRaD TERMINAL[1] command from a personal computer tied into the General (GCB) system using the following procedure:

T2[2]

```
NOSC Terminal program vers 1.15 of 1988 Jan 5
Configured for an IBM–PC using COM1:, at 9600 baud,
emulating a DEC VT100

#LO

#location 8

#CA

#call a50

#  CALL COMPLETED TO 0A50,1
```

[1] These commands, with instructions, may be obtained from the Customer Service Group, located in Building A33, Topside.
[2] In this document, computer input is shown in **boldface**.

<return>

[security information printed here]

`Username:` **`jdoe`**[3]

`Password:` **`abcdef`**

`Last interactive login on . . . (date, time)`

`TERM TYPE (VT100)?` **`<return>`**

You will be in the root directory upon successfully logging into WAHOO. The desired directory must be opened using standard UNIX operating procedures:

`SET DEF [.directory name]`

Routines stored on WAHOO are run using the command:

`RUN <routine name>`

Should you want to run another program not in the current directory, you must first return to the root directory before opening the new directory:

`SET DEF [-]`

`SET DEF [.new directory]`

A listing of regional data files may obtained by entering the proper director as specified above and entering:

`DIR *.<file extension .MBT, MOS, or MST>`

Files may be copied from one directory to another by using the command:

`COPY [FISHER.olddir]file.ext [FISHER.newdir]`

WAHOO is exited using the commands:

`LOGOUT`

`ABCDEF  logged out at . . .`

`<f10>`

A3. <u>Routine CKREEL</u>:

Start Routine CKREEL by entering **RUN CKREEL**. You then must enter the reel number of the 9-track tape containing the raw MOODS data. The reel number applied by NAVOCEANO is generally used, but with a suffix indicating that it is a copy of the original.

`ENTER REEL NUMBER TO BE CHECKED:` **`12345W`**

[3] Use lower case when entering administrative information into WAHOO.

The reel will be examined and the number of each type of observation and the location given by Marsden Square will be printed as shown in figure 7[4]. A data listing also may be obtained by exercising the second option below.

```
OPTIONS AVAILABLE:

  (1) READ MOODS DATA

  (2) LIST MOODS DATA

INDICATE OPTION DESIRED: 1
```

If a listing is desired, the sequential position in the file of the first and last observation desired must be given. This option is not normally used because of the extra time required and excessive data output.

```
ENTER # OF FIRST OB TO BE PRINTED (XXXX): 1

ENTER # OF LAST OB TO BE PRINTED (XXXX): 100
```

Errors encountered while reading the data can be listed if desired; however, this option normally is not exercised.

```
DO YOU WANT TO LIST ERRORS: N
```

The routine may be recycled as often as desired. However, the system operator must be contacted to dismount the original tape reel before routine CKREEL can be rerun.

A4. Routine XBT0

Routine XBT0 is started by entering **RUN XBT0**. You must then enter the name of the 9-track tape as in the previous section.

```
ENTER THE NAME OF THE ARCHIVED DATA TAPE: 12345W

IS THE NAME OF THE DATA TAPE CORRECT?  ANS Y OR N: Y[5]
```

The system will then request that the desired reel be mounted and verify that this has been done.

```
PLEASE MOUNT REEL 12345W

UNIT 10 OPEN TO READ TAPE 12345W
```

MOODS data files normally contain data from three sources. You may select to use all or only a part of the data:

```
INDICATE TYPE MOODS DATA DESIRED:

  (1) ALL DATA (XBT, OSTA, AND STD)

  (2) XBT AND STD DATA
```

4 Figure numbers in this appendix refer to figures from the main text.
5 Verification statements requiring a Y or N response are used throughout the computer dialogue. In the interest of simplicity, these statements will not be used henceforth in this text.

```
(3) XBT AND OSTA DATA

(4) OSTA AND STD DATA

(5) XBT DATA ONLY

(6) OSTA DATA ONLY

(7) STD DATA ONLY

ENTER CHOICE 1
```

The data files normally are contained in the first file on the tape reel. Because exceptions do occur, you will be asked to specify the file containing the desired data.

```
IS DESIRED DATA IN 1ST FILE OF TAPE? N

ENTER FILE NUMBER DESIRED: 2
```

It is expected that you will want to break the data into numerous subfiles. Thus, you are asked to provide a file name for each downloaded file. It is recommended that descriptive names, such as geographic names, be used.

ENTER NAME OF OUTPUT FILE: **NE_ALSKA**

Separation of large files into regional files is the most effective means of generating files of manageable size. This requires that file boundaries be established, including geographic quadrant of the earth and geographic limits for each of four sides.

> **Note:** A region can include data from a single geographic quadrant only. Should a region require data spanning the Greenwich Meridian, International Date Line, or Equator, separate files should be generated and merged later using the MS/DOS COPY command. This process also is used to combine data from different tape reels or files.

```
INDICATE QUADRANT:

  (1) NORTH LATITUDE, EAST LONGITUDE (NE)

  (2) SOUTH LATITUDE, EAST LONGITUDE (SE)

  (3) SOUTH LATITUDE, WEST LONGITUDE (SW)

  (4) NORTH LATITUDE, WEST LONGITUDE (NW)

ENTER NUMBER OF DESIRED QUADRANT: 4
```

You will be asked to define each of four boundaries (upper, lower, right, left) for the region, with up to eight terms for each polynomial.[6] For example:

```
BE SURE TO INSERT DECIMAL POINT IN TERM.
```

[6] See Routine LSTSQRS in appendix B to generate polynomial equations.

```
ENTER NUMBER OF TERMS FOR UPPER BOUNDARY: 1

        ENTER TERM 1: 55.
```

A grid with the terms for each of the four sides will be shown for verification. If a term is in error, it may be replaced by entering the column (horizontal), row (vertical) position of the erroneous data along with the correct polynomial.

```
DO YOU WANT TO DOWNLOAD ADDITIONAL DATA? N
```

You can either rerun additional programs or return to the PC by using the procedure outlined in section A2.

In some instances, all data for a desired region are not included on the same 9-track tape. If this is this case, rerun Routine XBT0 with all parameters unchanged except for the names of the regional tape reel and output files. It is suggested that the same regional name be used, but with numerical or letter suffixes. The file can then be combined using the UNIX concatenation command:

```
COPY / CONCATENATE area1.ext,area2.ext,area3.ext  area.ext
```

Note: Be sure to specify the extension to ensure that only the same type of data are included in the same file.

A5. Routine DWNLD

Routine DWNLD can be run only after regional files have been constructed using Routine XBT0. You may modify file size, time period, and water stratum as desired. It is expected that the files generated will be downloaded to a personal computer using the MCP command; therefore, it is recommended that the files be kept small both to permit rapid downloading and easily managed files.

Begin the program by entering **RUN DWNLD**. You must then indicate the type data to be processed for downloading:

```
SELECT TYPE RUN:

  (1) XBT TRACES

  (2) S-T-D CASTS

  (3) NANSEN CASTS

ENTER CHOICE: 1
```

The number of observations downloaded depends on the complexity of the region and the number of observations available. In a highly variable area, it is suggested that 100 to 200 hundred observations per month should be adequate to represent normal conditions.

```
NUMBER OF OBS SET TO 500.  IS THAT OK? N

ENTER NUMBER OF OBS DESIRED: 2000
```

Although the geographic area cannot be expanded from the parent file, a data filter can be used to diminish the size of the region downloaded. If this option is selected, you will be asked to enter four geographic boundaries as discussed in section A4.

```
DO YOU WANT TO USE A REGIONAL DATA FILTER? Y

ENTER NAME OF STORED DATA FILE: SWSOJ

ENTER NAME OF NEW DATA FILE (8-LTR MAX): SWSOJ1

DATA WILL BE SAVED IN FILE SWSOJ1.  IS THAT OK? Y

ENTER MINIMUM DEPTH DESIRED: 50

ENTER MAXIMUM DEPTH DESIRED: 800

DO YOU WANT TO PROCESS:

    (1) ALL DATA

    (2) BY MONTH

    (3) BY SEASON

ENTER CHOICE: 3

ENTER DESIRED SEASON:

    (1) WINTER (JAN-MAR)        (3) SUMMER (JUL-SEP)

    (2) SPRING (APR-JUN)        (4) AUTUMN (OCT-DEC)

1

DO YOU WANT TO RUN THE PROGRAM AGAIN? N
```

You can either rerun additional programs or return to the PC by using the procedure outlined in section A2.

A6. Routine XBT2A

Start Routine XBT2A by entering **RUN XBT2A**. You must then enter a descriptive title for the output. Each title should describe the region and physical characteristics[7] of the run. Specifics, such as name and type data contained in the data file, watermass characteristics, and geographic filters selected, etc., are included on the last sheet of the printer output. However, in the likelihood that several runs will be used for the same data set, it is suggested that relevant information be included in the title. A maximum of 40 characters are permitted in the title.

```
ENTER TITLE OF OUTPUT: SO CAL DEEP, T200: 5 TO 12; HIST SAL
```

Filters are required for each run. You may use broad filters to include all data or may limit the data examined by entering specific limits.

[7] Acoustic parameters generated by this program are defined in appendix B.

The optimal period for statistical processing is on a monthly basis. Longer periods should be used only to determine the general parameter minimas and maximas. The biweekly option, which uses 24 15.2-day periods, can be used to determine trends over short periods in areas where observations are plentiful.

```
ENTER STATISTICAL PERIOD DESIRED:

    (1) ANNUAL

    (2) SEMIANNUAL

    (3) QUARTERLY

    (4) BIMONTHLY

    (5) MONTHLY

    (6) BIWEEKLY  5

USE METRIC UNITS FOR ALL FUTURE INPUT
```

You may select the maximum depth (MAXD) to be examined in the statistical output. This selection is not trivial, because MAXD also determines the minimum depth required for included observations. For example, an observation extending to 356 m would be accepted if MAXD were 300 m, but not if the layer were 400 m. This feature can be used to assist separation of deep-water from shallow-water observations.

```
ENTER DEEPEST STATISTICAL LAYER TO BE EXAMINED

SHOULD BE 50, 100, 150, 200, 300, 400 M: 400
```

It may be desirable to separate data as a function of water mass. This is done by selecting a depth and temperature limits for the filter. For example, a temperature range of –2° to 30° C at a filter depth of 200 m would ensure that all XBT traces from the area would be extracted in temperate regions of the ocean. Filter depth should be deep enough to be free of significant annual temperature changes, but shallow enough to accept most of the data. Normally a depth of 150 or 200 m fulfills these criteria. Should only observations collected from the continental slope and adjacent shelf be desired, you might specify a minimum and maximum depths of 50 m and 300 m, respectively. In this case, truncated observations collected in deep water could be eliminated by selection of a geographic filter. Values falling within this filter will be accepted, all others discarded. If water mass values are not available from the physical oceanographic literature, the scatter diagram option of Routine TSZ in section A7 is used to approximate the temperature limits.

```
ENTER DEPTH OF TEMPERATURE FILTER: 200

ENTER MIN TEMP FOR FILTER: 5

ENTER MAX TEMP FOR FILTER: 12
```

The program examines the temperature gradient between 200 and 300 m to permit you to separate different water masses with similar temperature values at the same teat depth. This feature is useful when neighboring water masses have similar criteria at filter depth, but not at deeper levels.

```
DO YOU WANT TO CHANGE THE MIN AND MAX TEMP GRADIENTS

FROM -10.0 TO 1.0 ? Y

ENTER MIN TEMP GRAD FOR FILTER: -6

ENTER MAX TEMP GRAD FOR FILTER: 0
```

The name of the data file downloaded using Routine XBT0 must be entered. The file extension .MBT is not required. If the file cannot be found, it either does not exist or has not been copied from directory XBT0 to directory XBT2A.

```
ENTER NAME OF DATA FILE: SOCAL
```

The maximum depth criteria (ZMAX) permits you to eliminate data that extend below a given depth. For example, the default value of 800 m would accept data from T–4 (maximum depth: 460 m) and T–7 (760 m) probes, but would not include data from T–6 (2500 m) probes. This option can be used to separate shallow water data from deep water data. However, it can also be used in deep water to maximize the number of probes available, for example, of a near-surface feature such as layer depth in Northern Hemisphere summer. ZMAX must be equal or greater than MAXD; if not, it will be recalculated to MAXD plus 100 m unless directed otherwise.

```
MAX DEPTH IS SET AT 800 M. IS THIS OK? Y
```

The input is then displayed and you are given the opportunity to make changes. Proper use of this option can save considerable run time. When Routine XBT2A is recycled, this menu will appear with the parameters from the previous run, thus saving the effort of re-entering each number. For example, if a second water mass is to be examined, only the minimum and maximum values of the temperature filter and possibly the values for the temperature gradient filter need modification.

```
PERIOD = 1 MOS.

OBS LESS THAN 400 M NOT ACCEPTED

TEMP FILTER DEPTH = 200 M

NO OBS DEEPER THAN 800 M WILL BE EXAMINED

MIN AND MAX TEMP AT TEST DEPTH ARE 5.00 AND 12.00

MIN AND MAX TEMP GRADIENTS BTWN 200 AND 300 M ARE -6.0

AND 0.0

DATA FILE IS SOCAL

ARE THE INPUT DATA CORRECT?  ANS Y OR N  Y
```

The statistical data for each period may be saved for later processing by Routines CUMLTV or XSIG. If the data are stored, you will be asked to enter a name for the statistical file. The file extension .STA will appended to the file name automatically.

```
DO YOU WANT TO SAVE THE STAT DATA? Y

ENTER NAME OF STAT FILE: SCALDP
```

A 10-degree by 10-degree miniplot showing the number of observations per half degree may be printed if desired. Note that the data cannot be used where quadrants of the earth intersect. The program will generate the proper geographic coordinates for the upper right corner of the plot upon entry of data defining the lower left corner.

These data may be saved for use in Routine XBT3A. If the grid is saved, it is recommended that the same name as used for stored statistical data be used to keep you from being overwhelmed by different file names. The extension .XPL will be added automatically for a stored XBT miniplot.

```
DO YOU WANT A 10X10 MINIPLOT? Y

MINIPLOT WILL NOT WORK WHERE EQUATOR, GREENWICH MERIDIAN,

OR INTERNATIONAL DATE LINE INTERSECTS PLOT.

ENTER LAT OF LWR LEFT CORNER IN DEGREES (EG, 35): 30

 ENTER HEMISPHERE OF LL CORNER ( N OR S ): N

ENTER LON OF LWR LEFT CORNER IN DEGREES (EG, 125): 40

ENTER HEMISPHERE OF LL CORNER ( E OR W ): W

DO YOU WANT TO SAVE THE MINIPLOT TO THE DISK? Y

ENTER NAME OF MINIPLOT FILE (10-LTR MAX): SCALDP
```

Histograms of the distribution of temperature at test depth and the temperature gradient between 200- and 300-m levels may be generated. Both of these plots are useful in determining the presence of more than one water mass. Indications of the presence of multiple water masses are (1) multiple maxima and minima in lieu of a bell-shaped curve, and (2) a wide range of values (e.g., a 10-degree temperature spread without a noticeable maximum.

```
DO YOU WANT TO PRINT A TEMPERATURE HISTOGRAM AT DEPTH? Y

DO YOU WANT TO PRINT A TEMP GRADIENT HISTOGRAM AT DEPTH? Y
```

All acoustically related parameters can be generated using historical salinity values in lieu of default salinity of 35 parts per thousand (o/oo). Historical profiles may be entered by either of two methods: (1) quarterly profiles at standard oceanographic depths as imported from Routine TSZ or (2) a single profile entered manually. Salinity will be interpreted for each depth increment in the XBT profile regardless of the method used.

```
DO YOU WANT TO USE A HISTORICAL SALINITY PROFILE? Y

SELECT TYPE INPUT DESIRED:

  (1) RECALL STORED PROFILE

  (2) KEYBOARD ENTRY OF PROFILE
```

```
ENTER CHOICE: 1
```

The most common means of salinity input is using ocean station data downloaded by Routine TSZ. If this option is selected, then the file (with extension .SAL) first must be copied from Directory TSZ using the COPY command described in section A2.

```
DO YOU WANT TO USE A REGIONAL DATA FILTER? Y

ENTER NAME OF SALINITY FILE: SOCAL
```

If a manually entered salinity profile is desired, you will be requested to enter salinity values at the sea surface, 50, 100, 150, 200, 300, 400, 500, 600, and 800 m. For example:

```
ENTER SALINITY AT 0 M: 33.256

ENTER SALINITY AT 50 M: ....
```

The program provides the option of excluding data outside a set of four geographic boundaries. This procedure is useful in limiting the data set to a particular area such as the continental shelf or on one side of the historical location of an oceanic front to ensure that most samples are representative of a particular water mass. The procedure used to apply a geographic filter in Routine XBT0 is defined in section A4.

```
DO YOU WANT TO USE A REGIONAL DATA FILTER: N
```

In some instances, you might want to download temperature data from a specific depth for further analysis. For example, data downloaded from this program would be useful to examine surface temperature using harmonic analysis.

```
DO YOU WANT TO DOWNLOAD TEMPERATURE AT A SPECIFIC DEPTH? Y

ENTER NAME FOR TEMPERATURE FILE: SCALDP2

ENTER DEPTH FOR TEMP DATA: 200
```

The statistical listings normally are printed on the system standard (SYS$PRINT) using the day-time-group at the time designated, plus a system identifier (example: 073030$PRINT.LIS). Up to five copies of the listings may be printed; the default value is a single copy.

```
DO YOU WANT OUTPUT SENT TO A PRINTER? Y

ENTER NUMBER OF COPIES (MAX = 5): 1
```

You have the option to make as many runs as desired. If additional runs are made, an abbreviated data menu is used to set the program filters. This provides a considerable savings in run set up time.

```
DO YOU WANT TO RUN THE PROGRAM AGAIN? Y
```

A7. Routine TSZ

The initial set up procedure for Routine TSZ is similar to that for Routine XBT2A (section A6 above) except that only hydrocast (Nansen cast, file extension .MOS) and C–T–D/S–T–D (.MST)

data can be used as input. The ability to select maximum and minimum parameter values, a regional filter, period, etc., permits you to customize the run to provide data for a particular time and place.

After entering the plot title, you will be asked to indicate the type data to be processed:

```
SELECT TYPE DATA DESIRED:
  (1) HYDROCAST
  (2) C–T–D/S–T–D
ENTER CHOICE: 1
```

You must then designate the type output desired.

```
INDICATE TYPE PLOT DESIRED:

  (1) TS SCATTER PLOT

  (2) TS PROFILE(S): 1
```

The scatter plot provides a rough estimate of the relation between salinity (horizontal plot axis) and temperature (vertical axis) at a specified depth as shown in figure 12. Note that the plot is limited to a 20 x 20 array, with the printed number representing the number of observations falling within each bin. Thus, the granularity of each bin is a function of the temperature and salinity ranges selected. For example, minimum and maximum temperature values set at 0^{o} and 20^{o}C would result in each temperature bin having a value of 1 degree; whereas settings of 0^{o} to 10^{o}C would have 0.5-degree bins. Thus, when determining water masses delineators, it might be necessary to initially plot the entire spectrum of TS ranges followed by one or more plots using finer scales such as 0.25-degree bins. If a finer plot is desired, you should download S–T–D data to a PC and run Routine MDS as described in reference 4.

If the TS Profiles option is selected, the number of observations, mean and standard deviation are plotted at each standard depth for temperature, salinity, and sound speed for each period. The profiles also provide a general indication of the axial depth of the deep sound channel. Salinity profiles generated with this option may be saved for use with Routine XBT2A by answering affirmatively at the prompt:

```
DO YOU WANT TO SAVE THE SALINITY PROFILES: Y

ENTER THE NAME OF THE SALINITY FILE: SOCAL
```

Program termination is similar to that used for Routine XBT2A in the previous section.

A8. **Routine XBT3A**

Routine XBT3A generates a 10- by 10-degree plot similar to that produced by Routine XBT2A with two additions: (1) mean values and standard deviation of temperature, sound speed, salinity, and sigma–t plus number of observation are plotted as a function of 1-degree rectangles and (2) all data files (.MBT, .MST, and .MOS) may be accessed. Miniplots may be printed and saved as in Routine XBT2A (section A6) for later use in Routine MRGEXY (Section A11). Miniplots saved with this program have the extension .XPL of XBT data, .OPL for hydrocast data, and .SPL for C–T–D/S–T–D data.

The program is initiated by entering RUN XBT3A. The set up for Routine XBT3A is similar to Routine XBT2A, with the exception that the type data and output must be identified.

```
SELECT TYPE DATA DESIRED:

  (1) XBT

  (2) HYDROCAST

  (3) S–T–D/C–T–D

ENTER CHOICE: 2
```

If XBT data are selected, you have the option of printing either statistical data or number of observations at one of eight depths (0, 25, 50, 100, 150, 250, 300, or 400 m). If hydrocast or S–T–D/C–T–D data are selected, you may process additional information:

```
SELECT TYPE DATA TO BE PROCESSED:

  (1) TEMPERATURE

  (2) SOUND SPEED

  (3) SALINITY

  (4) SIGMA–T

  (5) # OBS PER 30–MINUTE RECTANGLE

ENTER CHOICE: 2
```

A9. Routine XSIG

Routine XSIG uses Student's t–test to determine significance between data sets generated with Routine XBT2A and saved in .STA files. Start the program by entering **RUN XSIG**. You then will be asked to enter the names of the two files that will be used in the comparison, e.g.,

```
ENTER NAME OF FIRST STORED STAT FILE: EPAC3

ENTER NAME OF SECOND STORED STAT FILE: EPAC3A
```

A list of temperature and acoustic parameters available for comparison will appear on the screen and the desired choice indicated.

```
PARAMETERS AVAILABLE FOR PROCESSING:

  (1) SEA SURFACE TEMPERATURE

  (2) TEMPERATURE AT 25 M

  (3) TEMPERATURE AT 50 M

      .
```

```
        .

        .

( ) SONIC LAYER DEPTH

( ) TEMP AT SONIC LAYER DEPTH

( ) TEMP GRAD BTWN 200 AND 300 M

( ) CUT-OFF FREQUENCY IN SURFACE LAYER

( ) SECONDARY SOUND CHANNEL AXIS DEPTH

( ) TEMPERATURE AT AXIAL DEPTH

( ) SOUND CHANNEL THICKNESS

( ) SOUND CHANNEL MAGNITUDE

( ) SOUND CHANNEL CUT-OFF FREQUENCY

ENTER SELECTION: 2
```

The program may be reiterated as often as necessary without renaming the data files. However, you have the option of changing the data files and making addition runs if desired.

A10. **Routine CUMLTV**

Routine CUMLTV combines statistical data saved previously with Routine XBT2A. The combined data is saved under a new file name with the extension .STA. The maximum number of data sets that can be combined with this routine is nine.

After starting the program by entering **RUN CUMLTV**, the following information is required:

```
ENTER TITLE OF COMBINED STATISTICAL SETS:

EPAC COMPOSITE

ENTER NAME OF NEW FILE: EAST PAC

ENTER NAME OF FIRST STORED STAT FILE 1: EPAC1

    .

    .

    .
```

The files will be combined and a statistical output will be printed for the combined files using a tabular output similar to that used for Routine XBT2A.

A11. **Routine MRGEXY**

Water mass distribution can be determined using Routine MRGEXY by combining miniplots generated by Routines XBT2A and XBT3A into a single set of plots. After starting the program by entering **RUN MRGEXY**, the set up is similar to the other programs:

```
ENTER TITLE: CALIFORNIA CURRENT

ENTER POSITIONAL INFO OF BASE PLOT:

  ENTER LAT OF LWR LEFT PLOT CORNER: 30

  ENTER HEMISPHERE OF LAT: N

  ENTER LON OF LWR LEFT PLOT CORNER: 125

  ENTER HEMISPHERE OF LON: W

ARE LAT AND LON CORRECT? Y
```

Note that the geographic location of the composite chart need not be the same as that of stored miniplots called by this program; an offset algorithm adjusts stored data to fit the desired coordinates.

All data for a single water mass must be input before the next water mass can be addressed. After entering the water mass title, you must enter the name and designate the source (.XPL, .OPL, or .SPL) of each stored miniplot file sequentially. A data set created from XBT data (file extension: .XPL) is in the same format as a set generated from hydrocast (.OPL) or C–T–D/S–T–D (.SPL) data. Thus, these sets may be summed to determine the total number of observations passing the designated filter. However, you must first copy the data sets into Directory XBT3A using the COPY command (section A2).

```
ENTER ID FOR WATER MASS #1: EPAC

ENTER NAME OF STORED DATA FILE 1 FROM EPAC: EPAC3

SELECT TYPE DATA DESIRED:

  (1) XBT

  (2) OSTA

  (3) STD

ENTER CHOICE 1
```

After each data set has been read, you will be asked if there are additional files for this water mass. Answer affirmatively if additional files are to be included; negatively if all files have been read.

```
ARE THERE MORE FILES FOR THIS WATERMASS? N
```

If all data have been read for a given water mass, you must indicate whether data from another water mass is to be processed.

```
ARE THERE ADDITIONAL WATER MASSES? N
```

The data will then be combined and miniplots printed showing the total number of observations and the percentage of each water mass by 30-minute and 1-degree rectangles.

APPENDIX B
SUPPLEMENTAL PC ROUTINES

The routines discussed in this appendix are written in PowerBASIC[1] for use on an IBM-compatible personal computer. Output is formatted for a LaserJet Series II printer.

B1. Routine LSTSQRS

Routine LSTSQRS is activated by entering **LSTSQRS**. You will be asked to enter the plot title followed by the input data.

```
ENTER NAME OF DATA SET: E. ANDAMAN SEA
```

Be sure that the data are entered in the proper format; if you want latitude as a function of longitude, you must first enter longitude, then latitude. After the data have been accepted, the data will be sorted in ascending order based on the magnitude of the x coordinate.

```
REGRESSION IS Y=F(X) FORMAT.

ENTER X AND Y SEPARATED BY A COMMA; 50 PTS MAX.  USE -999,0
TO END.

    1    5,102.4

    2    7,100.1

         .

         .

         .

    n    -999,0
```

After all the data have been entered, a grid of the inputs will be printed on the screen. You can either accept or modify the data at that time.

```
AVAILABLE OPTIONS:

   (1) ACCEPT DATA

   (2) CORRECT DATA

   (3) ADD A POINT

   (4) DELETE A POINT

ENTER NUMBER OF DESIRED OPTION: 1
```

[1] A product of Borland International.

If a point requires correction, enter the integer of the point in error and correct values:

```
ENTER INTEGER OF INCORRECT ENTRY AND CORRECTED DATA:
3,9,99.1
```

If a new data point is desired, enter the new coordinates and the program will automatically place them in the proper order in the array based on the magnitude of the term x.

```
ENTER NEW X AND Y VALUES:  17,94.3
```

Data may be deleted merely by entering the increment of that data point:

```
ENTER INTEGER OF DATA TO BE DELETED: 7
```

After the data array is accepted, you will have the option of printing the data. Normally, this is not required as the array will be printed on the final output.

```
DO YOU WANT TO PRINT THE RAW DATA?  N
```

The order of the regression must be entered. Although the routine can process ten order polynomials, it is rarely necessary to use more than five or six.

```
ENTER ORDER OF LINEAR REGRESSION (LINEAR = 1, ETC): 4
```

The program will print of the results of the analysis upon completion of the computations. You can print the analysis if desired:

```
DO YOU WANT A COPY OF THESE COMPUTATIONS? Y
```

Using the values provided in figure 18, the resulting polynomial is:

$$Y(i) = 127.0306 - 9.31768*X(i) + 1.178889*X(i)^2 \ldots$$

where Y: longitude and X: latitude.

A simple x–y plot is available to compare the fit of the polynomial to the raw data. If selected, you will be asked to enter plot title and axes set up. You will have an opportunity to review and, if necessary, modify the inputs.

```
DO YOU WANT GRAPHIC INPUT?  Y

ENTER HORIZ (X) AXIS LEGEND: LATITUDE

ENTER VERT (Y) AXIS LEGEND:  LONGITUDE

TITLE PLOT IS E ANDAMAN SEA.

HORIZONTAL AXIS IS 4 TO 16 WITH TICK MARKS EVERY 1 UNITS.

AXIS LEGEND IS LATITUDE.

VERTICAL AXIS IS 97 TO 103 WITH TICK MARKS EVERY 1 UNITS.
```

```
AXIS LEGEND IS LONGITUDE.

IS PLOT SETUP OK? N

SELECT PARAMETER TO BE CHANGED:

   (1) PLOT TITLE                 (6) MIN VALUE OF VERT AXIS
   (2) MIN VALUE OF HOR AXIS      (7) MAX VALUE OF VERT AXIS
   (3) MAX VALUE OF HOR AXIS      (8) TICK INTRVL OF VERT AXIS
   (4) TICK INTRVL OF HOR AXIS    (9) VERT AXIS LEGEND
   (5) HOR AXIS LEGEND

ENTER NUMBER OF PARAMETER TO BE CHANGED: 1
```

The analysis may be repeated without entering the original data:

```
DO YOU WANT TO TRY A DIFFERENT ORDER?  N
```

You now have the option of recycling the program with different data or ending the program.

```
DO YOU HAVE ANOTHER DATA SET? N
```

B2. **Routine XYPLOT**

Start Routine XYPLOT by entering **XYPLOT**. You will be asked to enter the plot title:

```
ENTER PLOT TITLE: DEEP SOCAL BIGHT — PCNT ZERO SLD
```

Several plot formats are available, all of which plot statistical data as a function of month using printouts generated by Routine XBT2A. Options 1 through 3 plot mean and standard deviation from the mean, while the fourth option plots the mean only. The fifth option permits you to plot as many as six different parameters. This latter option is helpful in illustrating similarities or differences among parameters. All plots include a trend line, as determined from the January and December means, at the start and end of the monthly data. Typical data input for each option is shown in brackets. (Routine XYPLOT does not include this information.)

```
INDICATE TYPE UNITS:

   (1) DEPTH (MEAN & STD DEV)          [layer depth]
   (2) TEMPERATURE (MEAN & STD DEV)    [water temperature]
   (3) FREQUENCY (MEAN & STD DEV)      [cut off frequency]
   (4) PERCENT (MEAN ONLY)             [% useful SND CHAN]
   (5) OTHER (USER SELECTED)           [any parameter]
   (6) END PROGRAM
```

```
ENTER APPROPRIATE NUMBER: 3
```

The assumption is made that all input data are in metric units. However, if depth or temperature data are processed, you will be asked to select output units:

```
INDICATE UNITS OF OUTPUT DATA:

  (1) METRIC (METERS, DEGR CELSIUS)

  (2) ENGLISH (FEET, DEGR FAHRENHEIT)

ENTER (1) OR (2): 1
```

You must then define the limits of the vertical axis by answering the appropriate queries. Note that these units will not be converted to English units if English units were selected. In most cases, the interval between tick marks will be determined automatically.

It is suggested that data entry be made using the keyboard number pad. Note that the keyboard number pad "plus" sign (+) is automatically reconfigured by the computer as a comma to assist in data entry for Options 1 through 3 of the main menu. Leading and trailing zeros may be omitted. Depending upon the option selected, the computer will print a message reminding you of this capability.

If input consists of mean monthly values and standard deviation, the data will be entered in the following format:

```
1      17.03+1.12

2      16.54+0.1

3      . . .

4      et cetera
```

If standard deviation is not required, only the mean value is entered at the prompt, e.g., 60.2. In either case, you are given the opportunity to correct errors after the entire array has been entered.

After the graphic is plotted, you will have several seconds to examine or capture the screen by whatever method you select. The screen will be erased upon pressing **<enter>**. You will then be given the option of continuing or ending the program.

APPENDIX C
DEFINITIONS OF OCEANOGRAPHIC TERMS

Best Depth: The best depth for a submarine to avoid detection by a hull-mounted sonar. This assumption is based on the premise that maximum downward refraction of sonic energy will occur at the depth of the maximum negative sound speed gradient, thus causing short horizontal sonar ranges. For the purpose of this paper, the depth stratum containing the minimum gradient must have a thickness of 10 m or more. This definition disagrees with the adage that defines best depth to avoid detection as sonic layer depth plus 100 meters.

Cut-off Frequency (COF): The maximum frequency, in hertz, that will remain entrapped within a sound channel. Also called low-frequency cutoff. For the surface layer, COF is defined as:

$$Fo = 0.3978 * V_o^{1.5} / (SLD * (V_{sld} - V_o))^{0.5}$$

where V_o and V_{sld} are sound speed at the surface and sonic layer depth, respectively. Not computed for near surface layers less than 10 m thick; ignored for frequencies greater than 5.2 kHz.

Cut-off frequency for sound channels below the surface duct is calculated using:

$$Fc = 0.2652*V_a^{1.5} / (\Delta Z * (V_b - V_a))^{0.5}$$

where ΔZ is sound channel thickness and V_a and V_b are sound speed at the sound channel axis and the sound channel boundaries, respectively. Not computed for sound channels less than 10 m thick.

Deep Sound Channel: A subsurface duct for long-range transmission of acoustic signals. Axial depth of the channel is the depth of minimum sound speed between the sea surface and the ocean floor. Also referred to as the primary sound channel.

Half Channel: The special case where the sound speed profile exhibits a minimum at the sea surface and a maximum at the sea floor. By definition, neither sonic layer nor sound channels may occur in a half channel. Normally a winter phenomenon associated with subpolar regions and the Mediterranean Sea.

Near-surface Layer: The layer extending from the sea surface to sonic layer depth.

Secondary Sound Channel: A sound channel located between sonic layer depth and the axial depth of the primary sound channel. Also referred to as a near-surface sound channel to distinguish it from the deep sound channel. Channel thickness is the depth interval between the sound speed maxima denoting the top and bottom of the sound channel. More than one, or multiple channels, may occur on the same profile.

Sigma-T: An abbreviated form of density:

$$\sigma_t = 1000 * (\varrho - 1.0)$$

where ϱ is density. For example, sigma–t of 28.5 equates to a density of 1.0285 gms/cm$_3$.

Sonic Layer Depth (SLD): The depth of maximum sound speed above the deep sound channel axis.

Surface Channel: An acoustic duct between the sea surface and the sonic layer depth.

Useful Sound Channel: A secondary sound channel with a cut-off frequency of less than 800 Hz.

Zero layer Depth: The special case where sonic layer depth occurs at the surface. Occurs most frequently in tropical and subtropical regions where surface winds are insufficient to cause mixing.

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Program WAHOO uses a Sun SPARC 10 minicomputer to process and analyze temperature, salinity, and sound speed data in various formats. The data, extracted from the Master Oceanographic Observation Data Set (MOODS) files maintained by the Naval Oceanographic Office, must be reformatted into regional files prior to analysis. This document provides guidelines required to process and analyze the MOODS data, thus providing valuable information required to characterize the oceanic and acoustic properties of an area.

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